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(54) ROTARY TABLET PRESS

(71) We, KILIAN & Co. G.m.b.H., a German Company of Emdener Strasse 10, D 5000 Koln 60, Federal Republic of Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to a rotary tablet press.

British Patent No. 1,154,289 describes and claims a rotary tablet press in which, with a view to keeping the weight of the tablets produced constant, the filled volume of the tablet moulds at the filling or proportioning station is controlled in dependence upon the pressure with which the tablets are pressed at the pressing station. This is achieved by feeding control pulses dependent upon the pressing pressure to a dial-type measuring instrument having two switch contacts, which when closed switch on a servomotor in one or other direction. The servomotor is at the filling station and adjusts the vertical position of the bottom ram of the mould and thus the volume of the mould which is filled. The control pulses are derived from strain gauges which are arranged on the bearings of the pressure rollers which press the top and bottom rams towards one another at the pressing station.

This known arrangement has the disadvantage that the amounts charged to the moulds, which are dependent on the pressing pressure, can easily be controlled too high or too low since the filling station and pressing station are arranged at a relatively large distance from one another and a number of mould cavities or bores which are already travelling between the filling station and pressing station and contain incorrect charges still pass through the pressing station and cause the latter to send further control pulses to the filling station.

An additional disadvantage of the known arrangement is that relatively large deviations in the size of the charges of the moulds, caused by external conditions, cannot be detected. By way of example, if there is no powder left for filling the moulds, the measuring station continues to send control pulses to the filling station and as a result causes the bottom ram to assume an ever lower position with the aim of increasing the filling volume. In actual fact, however, no more tablets are being produced. On the other hand, it is possible that the supply of the powder to be formed into tablets is interrupted for a relatively long time because of bridge formation in the supply flow. As a result of continuing control pulses, the filling volume is then enlarged up to a maximum. If the bridge in the powder then collapses and the powder suddenly flows forward in large quantities, some moulds are filled to excess and when they reach the pressing station, the pressing pressure rises far above the highest permissible value before the desired charge volume can be again restored. As a consequence, serious damage to the tablet press can occur, since it may not be equal to such overloading.

According to the present invention, there is provided a rotary tablet press having control means which, in order to reduce variations in tablet weight, control the volume of the tablet moulds at a filling station by causing adjusting means to vary the position of bottom rams of the moulds in dependence upon the table pressing pressure at a pressing station, the control means including delay means which, after an adjusting action by the said adjusting means, interrupts power supply to the adjusting means for a length of time, and monitoring means which, if there occurs a predetermined number of successive adjusting actions of the adjusting means which are all adjustments in the same sense, initiates a warning signal and/or causes cessation of the operation of the press.

The provision of the monitoring means can provide the advantage that deviations in the size of charges to the moulds from the nominal value and lasting over a relatively long time are made apparent to the operatives by for example an optical or acoustic signal or by the stopping of the machine, so that the cause of the disruption can be detected and eliminated, if the ma-

chine is unable to be automatically re-adjusted. The delay means may be arranged to interrupt the power supply periodically.

By this arrangement of a delay means in the control means, insensitive control, i.e. too rapid adjustment of the filled volume of the moulds, can be avoided. Preferably, the period of interruption of the power supply is at least equal to the time of travel of a tablet mould from that filling station to the pressing station, so that the effect of an adjustment of the filled volume of the moulds is felt before a further adjustment is made.

In one particular preferred arrangement, the said adjusting means is a servomotor arranged to adjust the stroke-height of the bottom rams, the operation of the servomotor being controlled by a dial-type measuring instrument to which control pulses dependent upon the pressing pressure are fed and which has two switch contacts by which the servomotor is operated in one or other direction, the delay means being a delay switch in the control circuit of the servomotor which switch, after closing of the control circuit by one of the said switch contacts of the measuring instrument, periodically opens and closes the control circuit of the servomotor, and the monitoring means being a counter with two switching magnetic coils which is incorporated into the control circuit of the servomotor, the said coils being respectively associated with the switch contacts of the measuring instrument which respectively cause the forward and reverse travel of the servomotor, each coil resetting the counter to an initial value before commencing the counting of the number of successive travels in the same sense, in forward or reverse as the case may be, of the servomotor.

In this embodiment the servomotor only switches on for a short time when deviations in the charge quantities from the rated value occur and is then switched off again by the delay switch, so that further control pulses which emanate from mould charges which are underway to the pressing position, remain disregarded. Preferably, it is only when the next, already corrected mould charge again reaches the pressing station that the pulse emanating from this corrected charge is measured and taken into account, after the delay switch has again closed the circuit. If a deviation from the rate or nominal value in one or other direction is still detected, the servomtor is then once again switched on.

The delay switch can have a bimetallic switch element through which the servomotor current flows, the switch having an open time which is substantially longer than the closed time, the ratio between closed time and open time being for example 1:5. Such a bimetallic switch can be of very simple construction and have a small tendency to breakdown. The delay time of the bimetallic switch is preferably adjustable, so as to be able to adapt it to the speed of rotation of the mould plate or table of the rotary press.

In order to be able to vary the tolerance range of the weight of the tablets, the switch contacts of the dial-type measuring instrument are preferably adjustable, so that different limit values for the maximum and minimum pressing pressures which are to set the control mechanism in operation can be set.

As in general the pressing pressure always fluctuates between zero and a maximum value, because of the particular nature of rotary tablet presses as determined by their construction, it is expedient that a peak value rectifier should be connected in the circuit transmitting the control pulses before the above-mentioned dial-type measuring instrument, so that the said instrument receives a signal which is always constant and which corresponds to the respective last maximum value.

One embodiment of the invention will now be described by way of example with reference to the accompanying drawing in which the single figure shows diagrammatically a circuit diagram of a rotary tablet press embodying the invention.

In the illustrated rotary tablet press which apart from its control means is of a known kind and is not shown in detail, a plurality of moulds are arranged in a circle on a rotating mould table, the tablet powder to be processed being introduced into the moulds at a filling station, the powder then being consolidated into tablets by pressing rams which move upwardly and downwardly at a pressing station arranged at a distance from the filling station. When pressing the tablets, the top and bottom rams are guided between pressure rollers. The pressing pressures thus established is measured on the pressure members and is standard for a given charge size and tablet weight when the consistency of the tablet powder introduced at the filling station is the same. If the pressing pressure at the filling station deviates upwardly or downwardly from the rated or nominal value, too much or too little tablet powder has been introduced at the filling station. It is then necessary to correct the size of the charge and to introduce less or more powder, respectively, into each mould. This is effected by moving the bottom rams, which form the lower end of the moulds at the filling station, to a higher or lower level, in order to reduce or to increase the filled volume of the moulds and as a consequence to reduce or increase the weight of the tablets. The pressing pres-

sure at the pressing station is then accordingly smaller or greater, when less or more powder is compressed between the top and bottom rams in the mould to the same volume at the pressing station.

In order to vary the vertical position of the bottom ram in the region of the filling station, it is necessary to adjust the position of a guide rail or cam 10 in the region of the filling station, on which cam the bottom rams slide as they revolve with the mould table. For this purpose, the guide cam 10 is provided with a spindle 11, which is adjusted by a stationary, rotatable spindle nut 12, which in its turn is driven by a servomotor 13. By means of a control arrangement 14 which is shown diagrammatically in the drawing, the servomotor 13 is switched on in one or other of its directions, i.e. for forward or rearward travel, the said control arrangement receiving its control pulses from a measuring station 15 arranged on the pressure members of the pressing station. For this purpose, the pressing station of the machine is provided with a pressure-measuring arrangement which is not shown in detail and which can, for example, consist of strain gauges in a bridge circuit arranged on the bearings of the pressure rollers or of a quartz crystal connected with suitable measurement converters and amplifiers. Such strain-measuring arrangements on such machines are known and are for example described in German Offenlegungschrift No. 1,627,927 (British Specification 1,154,289), and therefore do not need to be more fully explained herein.

In the present arrangement, the signal corresponding to the pressing pressure occurring at the measuring position 15 is converted in a measuring amplifier-converter 16 into an electric voltage signal. Since the pressing pressure constantly swings backwards and forwards between the zero value and a maximum value, because of the principle on which the machine operates, a peak value rectifier 18 is connected to the output 17 of the measurement value converter 16, which rectifier supplies at its output 19 a constant signal corresponding to the respective last maximum value. This signal is fed to a dial-type measuring instrument 20, which indicates by means of its pointer 21 the value of the signal supplied to it.

Coupled to the pointer 21 is a rotatable contact arm 22 of the dial instrument, which forms part of a control circuit 23, 24 of the servomotor 13 and co-operates with two adjustable switch contacts 25 and 26, one of the said contacts (25) switching on the forward movement of the servomotor 13 through a relay 29, while the other contact (26) switches on the reverse movement of the said motor through a relay 30.

Since the filling station and the pressing station are disposed at positions spaced from one another on the machine, it can easily happen that all moulds which are travelling from the filling station to the pressing station do not have the correct charge when the measuring station 15 at the pressing station first sends out a signal which indicates on the measuring instrument 20 a charge which is too large or too small and causes the contact arm 22 to touch either the switch contact 25 or the switch contact 26. So as to prevent the moulds which have already moved past the filling station at the time of the first correction from sending additional measurement signals with the result that the contact bridges 22, 25 or 22, 26 remain closed and the servomotor 13 continues to run and constantly re-adjusts the guide rail 10 in the same direction until the first mould with a corrected size of charge has reached the pressing station, a bimetallic delay switch is included in the control circuit 23, 24 of the servomotor 13, the switch element 32 of the said switch being heated when current flows and opening a contact 33 included in the line 23. The driving circuit 27, 28 of the servomotor 13 is consequently broken after the motor 13 has run for a short time, so that the measurement signals which emanate from the moulds with still uncorrected charges remain disregarded.

Since the current in the control circuit 23, 24 of the servomotor has been interrupted, the switch element 32 of the bimetallic delay switch 31 cools down again and recloses the contact 33, so that the servomotor 13 can be switched on again as soon as the contact arm 22 of the dial-type measuring instrument 20 reaches one of the switch contacts 25 or 26 because of another signal indicating an incorrect charge. Thereafter the delay switch 31 again opens the circuit after a short time. This switching cycle is repeated until the correct size of charge is reached, for which however usually only a single switching step is necessary.

As is indicated in the drawing, a counter 33*a* having two step-by-step mechanisms 34, 35 is included in the control arrangement, one of the said mechanisms (34) being connected to the line 36 which connects the switch contact 25 to the relay 29 for switching on the forward running of the servomotor 13. The other stepping mechanism 35 is connected to the line 37, which connects the switch contact 26 and the relay 30, which switches on the servomotor 13 for reverse running. Each of the stepping mechanisms 34 and 35 is so designed that its respective first pulse switches the counter 33*a* initially back to zero before the counter starts to count forward again.

Associated with the counter 33*a* is a limit

switch 38, which closes the signal circuit 39 when a predetermined number on the counter 33 is reached and initiates an optical or acoustic warning signal 40 and/or stops the drive means of the press.

The counter also includes a magnetic coil 41 which sets the counter 33*a* back to zero whenever the driving motor for the rotary press is switched on. Thus the counter always starts from zero upon restarting of the press.

To improve the operation of the switches and contacts, these have associated spark-quenching capacitors 42.

The manner in which the illustrated arrangement operates is as follows:

Before switching on the machine, the switch contacts 25 and 26 are adjusted to the spacing corresponding to the permitted tolerance range for the maximum or minimum pressing pressures, which in turn correspond to the highest permissible and lowest permissible size of charge. Furthermore, the bimetallic delay switch 31 is so adjusted in accordance with the speed of rotation of the mould plate that its open time corresponds to the travel time which a mould requires for travelling from the filling station to the pressing station. The machine is then switched on.

As long as the pressing pressure has the prescribed value, all moulds have the same filling quantity and all tablets have the same weight. The pointer 21, and the contact arm 22 which is connected to it, then assume the position shown in the drawing, in which the contact arm 22 is situated between the two switch contacts 25 and 26. In this position, both contact bridges and the contacts 43 and 44 associated with the relays 29 and 30 are open and the servomotor 13 does not run, although signals are continuously emitted from the measuring position 15, which signals are reformed in the converter 16 and are rectified in the peak value rectifier 18.

As soon as the pressing pressure at the measuring position 15 for example falls below the lowest permissible value within the tolerance range, the pointer 21 is moved in a counter-clockwise direction. Simultaneously, the contact arm 22 is rotated in the same direction and touches the contact 25, as a result of which the control circuit 23, 24 is closed and current is supplied to the relay 29 via the line 36. The relay 29 closes the contact 43, as a result of which the main circuit 27, 28 of the servomotor 13 is closed and the motor is switched on for forward movement.

The switch element 32 of the bimetallic delay switch 31 lying in the circuit 23, 24 is heated by the flow of current and, after a short time, opens the contact 33. As a result, the circuit 23, 24 is again broken, the relay 29 falls off and opens the contact 43, so that the servomotor 13 is once again stopped.

The switch element 32 of the delay switch 31 now slowly cools down again. Meanwhile, the mould table continues to rotate and the following, incorrectly filled moulds pass through the pressing station. The measuring position 11 emits measuring pulses corresponding to these incorrect charges and these pulses are indicated on the dial-type measuring instrument 20 and cause the contact arm 22 once again to bear against the switch contact 25. The control circuit 23, 24 is however opened at the contact 33, so that the relay 29 is unable through the contact 43 to close the main circuit 27, 28 and is unable to set the servomotor 13 in operation.

However, as soon as the mould with the first, already corrected filling quantity passes through the pressing station, the switch element 32 of the bimetallic delay switch 31 has cooled down to such a degree that the contact 33 is again closed. The measuring pulse of this mould with a corrected size of charge, and received at the measuring position 11 is forwarded to the measuring instrument, in the same way as the preceding measuring pulses. If it is indicated that the correction has still not been sufficient and the pressing pressure and size of charge are still too small, the control circuit 23, 24 between the contact arm 22 and switch contact 25 is once again closed and the servomotor 13 is switched on, and this motor, via the spindle nut 12 and the spindle 11, lowers the guide rail or cam 10 still further, so that the bottom ram assumes a lower position in the region of the filling station and the filling volume of the moulds is further increased. At the same time, the switch element 32 of the delay switch 31 is again heated up, the contact 33 is opened and the servomotor 13 is once again stopped by the relay 29. The cycle is repeated until the correct pressing pressure and thus also the correct charge size are reached.

If it is found that the correction has been too large, or if the pressing pressure exceeds the highest permissible amount because of increasing charge size, the measuring pulses coming from the measuring position 15 cause a rotation of the pointer 21 and hence also of the contact arm 22 on the measuring instrument in the clockwise direction. As a result, a connection is made between the contact arm 22 and the switch contact 26 which, through the line 37, causes the relay 30 to pull up, closing the contact 44, whereby the servomotor 13 is switched on for reverse movement. As a result, the spindle nut 12 is turned in such a way that the guide rail 10 and, with it, the bottom ram in the region of the filling station are lifted and

hence the filling volume of the mould is reduced. At the same time, the switch element 32 of the delay switch 31 again heats up and opens the contact 33, so that the servomotor 13 is again switched off until the switch element 32 of the bimetallic switch has cooled and the mould with the corrected charge has reached the pressing station. The measurement signal emanating from this mould is then transmitted to the dial-type measuring instrument and the latter, according to the deflection of the contact arm 22, initiates a corrective movement of the servomotor in the positive or negative sense or does not switch on this motor.

The effect of each closing of the control circuit 23, 24 is that the counter 33*a* is advanced by one step by the stepping mechanisms 34 or 35 actuated through the lines 45, 46. The advancing movement can however always be effected from the same line 45 or 46. For example, if three pulses reach the stepping mechanism 35 in succession through the line 45, the counter 33*a* is stepped forward by three steps. If the circuit is thereupon closed by means of the switch contact 25, the stepping mechanism 34 receives a pulse through the line 46. As a consequence, the counter 33*a* is first of all set back to zero. Each following pulse then advances the counter 33*a* by one step. Each change in the control pulses from line 45 to 46 and *vice versa* thus initially causes the resetting of the counter 33*a* to the initial value.

If the counter reaches a specified, pre-set maximum number, for example, the number 8, the limit switch 38 is thereby closed, this switch closing the signal circuit 39, whereby the optical or acoustic signal 40 is produced and the machine is switched off. In other arrangements, only an acoustic or other warning may be provided, or the press may be shut down and no specific warning given.

When the machine is switched on again, the counter 33*a* receives a pulse via the magnetic coil 41 and this pulse again sets the counter 33*a* back to zero.

In the illustrated embodiment, the filled volume of the moulds can be precisely controlled in dependence on the pressing pressure. Furthermore, the risk of overloading of the machine is greatly reduced.

WHAT WE CLAIM IS:—

1. Rotary tablet press having control means which, in order to reduce variations in tablet weight, control the volume of the tablet moulds at a filling station by causing adjusting means to vary the position of bottom rams of the moulds in dependence upon the table pressing pressure at a pressing station, the control means including delay means which, after an adjusting action by the said adjusting means, interrupts power supply to the adjusting means for a length of time, and monitoring means which, if there occurs a predetermined number of successive adjusting actions of the adjusting means which are all adjustments in the same sense, initiates a warning signal and/or causes cessation of the operation of the press.

2. Rotary tablet press according to claim 1 wherein the said adjusting means is a servomotor arranged to adjust the stroke-height of the bottom rams, the operation of the servomotor being controlled by a dial-type measuring instrument to which control pulses dependent upon the pressing pressure are fed and which has two switch contacts by which the servomotor is operated in one or other direction, the delay means being a delay switch in the control circuit of the servomotor which switch after closing of the control circuit by one of the said switch contacts of the measuring instrument, periodically opens and closes the control circuit of the servomotor, and the monitoring means being a counter with two switching magnetic coils which is incorporated into the control circuit of the servomotor, the said coils being respectively associated with the switch contacts of the measuring instrument which respectively cause the forward and reverse travel of the servomotor, each coil resetting the counter to an initial value before commencing the counting of the number of successive travels in the same sense, in forward or reverse as the case may be, of the servomotor.

3. Rotary tablet press according to claim 2, wherein the counter has associated with it a limit switch which initiates a warning signal and/or switches off the drive means of the press when a predetermined number on the counter is reached.

4. Rotary tablet press according to claim 2 or claim 3 having a magnetic coil arranged to reset the counter to zero when the driving motor of the press is switched on.

5. Rotary tablet press substantialy as herein described with reference to and as shown in the accompanying drawing.

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1475272 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*